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SUSTAINABLE ENVIRONMENTAL SANITATION AND WATER SERVICES

Performance evaluation of induced recharge project

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AVAILABILITY OF POTABLE groundwater in areas characterized by low rainfall is a prime requisite for mankind. If the available groundwater is not of suitable quality, then the cost of providing drinking water to the burgeoning population inhabiting the area tends to be prohibitive. In such cases, the relief measures should include efforts to improve the groundwater quality

Parts of the area falling under the alluvial valley of the Purna river basin in Amravati district of Maharashtra state in India have a groundwater salinity problem. Shingnapur village lies between latitude 20^0,29', 15"N and longitude 76^0,56', 45"E. Climatically the study area is characterized by a hot summer and general dryness throughout the year except during monsoon and the average annual rainfall is 790 mm.

The Groundwater Surveys and Development Agency of Maharashtra State has taken up an "Induced Recharge Project", whereby the river water of good quality is intended to be used for recharging the groundwater in the aquifers adjoining the river courses. A large number of wells have been drilled along the riverbanks and operated to create a reverse groundwater level gradient.

Purna River is a tributary of Tapi River. The drainage pattern of Purna River in general is dendritic and at places it is parallel to sub parallel type. All the tributaries except the river Purna are seasonal. According to Balpande et.al. (1997), the soils are very deep (>140cm) and fine textured, and very dark grayish brown to dark brown in colour. It is calcareous and moderately to strongly alkaline the Calcium being dominant followed by Magnesium, Sodium and Potassium.

Geologically the area is a part of Quaternary sediments. Pre-Quaternary geology and Quaternary geology is dealt with after the work of Ravishankar (1987) and Tiwari et.al. (1996). Purna alluvial tract is having thick alluvial deposits and which appears to be fluvial origin and were deposited in the actively subsiding graben or fault trough. The CGWB, based on detailed survey and exploratory drilling at 28 sites has classified subsurface geology of alluvial deposits in two broad groups as (C.G.W.B. 1998). **Younger Alluvium** is about 70-80m thick consisting of sub-angular to surrounded gravels with sand, silt and clay. and consisting of coarser sediments while **Older Alluvium** is more than 250m thick consists mainly of yellowish clay with gravel and sand at the base with finer sediment.

Methodology

In view of the evaluation of performance of induced recharge project a stepwise approach has been followed as discussed below:

Data acquisition: In the present study seven samples were collected for the period of June 1998 to May 1999 and the concentration of major cations and anions in groundwater were determined by chemical analysis using standard procedures in the laboratory of Ground Water Surveys And Development Agency, Amravati, Maharashtra.

Validation: Validation of data is carried out by Ion balance, Na^+/ Cl^-ratio CO_3^{--} balance.

Data Processing and Interpretation: The information generated from the above analyses along with the background information of geohydrology was processed to draw meaningful conclusions for establishing chemical changes with time.

Results and discussion

Statistical Analysis: The results of statistical analysis of the chemical data are represented in Table No 1. and inter correlation among major ions is represented in Table No. 2. Following inferences may be drawn.

i. Coefficient of variance values suggest that wide variation is observed in TDS, Na^+, Ca^{++}, Mg^{++}, Hardness, HCO_3^-, $Cl^-$and SO4^{--} while low variation is observed in pH, Temp. Fe^{++}, F^- and NO_3^-.
ii. High correlation coefficient is observed among Na^+, Ca^{++}, Mg^{++}, Cl^-, TDS, EC and SO_4^{--}, which suggest strong inter dependence among the above ions and negative (and small) correlation of the above ions is observed with HCO_3^-. Increasing trend of HCO_3^- suggest that saline water in the aquifer is getting diluted by modern precipitation of water. Low correlation shown pH, F^-, Fe^{++}, NO_3^- and K^+ indicates insignificant interdependence with above parameters.

Chemical analysis

Time series analysis of chloride: the declining trend of Chloride and TDS values (Table No 4) are reflected which shows declining salinity (Fig. No 2).

Box-whisker plot: this diagram (Fig. No 1) explains the changes in water quality with different seasons. The lower values of Cl^- in monsoon season is pointing towards recharge due to rains while moderate values of Cl^- in winter season is because of contribution of groundwater recharge

dominance and in summer season values of Cl^- are higher indicating negligible to nil recharge from any source

Piper diagram (Davis and Deweist 1967)**:** In order to know the seasonal variations of chemical parameters in groundwater the water type of the study area is classified as Monsoon, Winter and Summer Water Type.

Hydrochemistry of groundwater is evaluated by plotting the cations and anions in the Piper's Trilinear diagram (Piper 1953)(Fig. No. 3) and the following inferences are drawn.

Monsoon Water Type: For anion triangle, Bicarbonate is dominant more than chloride while in cation triangle, water type is of Na^+- Ca^{++}- Mg^{++} dominant Out of 3 samples, 1 sample is showing water type where alkalis exceeds than alkaline earths while rest 2 samples are showing alkaline earths exceeds alkalis. All samples are showing secondary alkalinity while rest- localities having no one cation-anion pair exceeds 50%.

Winter and Summer Water Type: Type of water is located in mostly chloride quadrant of anion triangle, while exclusively all samples lying in cation triangle are showing Na^+- Ca^{++}- Mg^{++} dominant. All samples are showing strong acid exceeds than weak acid and secondary alkalinity.

Geochemical evolution: Mixing line is drawn in between fresh water corner to seawater as given by Appoloo and Postma (1993). Points lying above this line suggest sulphate reduction, negative ion exchange and calcium carbonate deposition while points lying below this line suggest positive ion exchange and calcium carbonate solution. Geochemical evolution of the water types has been given on the basis of plotting the data on piper diagram and following inferences are drawn:

Monsoon water is lying below or adjacent to mixing line where ion exchange and Calcium carbonate solution plays very important role in changing their composition.

Summer and winter water type are lying above the mixing line, which indicate that base exchange, sulphate reduction and calcium carbonate deposition. Most of the data is showing calcium carbonate deposition as the dominant process in converting water type.

Conclusions

This information of statistical analysis can be used to rationalise the monitoring network of the study area. For salinity oriented monitoring, F^-, Fe^{++} may be discarded due to low values of coefficient of correlation and for K^+ and NO_3^-, frequency should be less while Na^+, Ca^{++}, Mg^{++}, Cl^-, TDS, EC, SO_4^{--} and HCO_3^- should be frequently monitored duo to high values of coefficient of correlation.

The time series analysis indicates the declining trend of TDS and Chloride values which shows declining salinity. Box-whisker plot explains the changes in water quality with different seasons. The lower values of Cl- in monsoon season is pointing towards recharge due to rains while moderate values of Cl- in winter season is because of contribution of groundwater recharge dominance and in summer season values of Cl- are higher indicating negligible to nil recharge from any source.

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Table 1. Results of Chemical analysis

Sr NO	Lab Sample NO		74	67	53	49	36	41	32
	Sample ID		SHIN-17-15/07/1998	SHIN-17-30/09/1998	SHIN-17-30/10/1998	SHIN-17-03/01/1999	SHIN-17-16/03/1999	SHIN-17-10/04/1999	SHIN-17-03/06/1999
1	pH		8.20	7.70	7.10	7.20	7.20	7.20	7.10
2	EC	umho/cm	1830.00	3500.00	7330.00	11400.00	13500.00	13840.00	3190.00
3	TDS	mg/L	1171.00	2240.00	4691.00	7296.00	8640.00	8858.00	2042.00
4	NO_3^-	mg/L	10.00	32.00	45.00	15.00	60.00	55.00	95.00
5	Alkalinity Phen	as CaCO3 mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	as CaCO3 mg/L	400.00	350.00	300.00	160.00	40.00	30.00	250
7	Hardness	as CaCO3 mg/L	350.00	510.00	3000.00	3400.00	4700.00	4060.00	700.00
9	Ca^{++}	mg/L	60.00	100.00	880.00	800.00	1160.00	1376.00	140.00
10	Mg^{++}	mg/L	48.00	62.40	192.00	336.00	432.00	148.80	84.00
11	Na^+	mg/L	160.00	410.00	690.00	860.00	1050.00	980.00	438.00
12	K^+	mg/L	1.00	1.00	2.00	1.00	1.00	1.00	2.00
13	Cl^-	mg/L	158.00	651.00	2200.00	3290.00	4620.00	4620.00	826.00
14	SO_4^{--}	mg/L	48.00	140.00	420.00	365.00	475.00	435.00	145.00
15	CO3	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	HCO_3^-	mg/L	400.16	350.14	300.12	159.82	40.02	30.01	250.10
17	F^-	mg/L	0.80	0.80	0.80	0.50	0.80	0.60	0.60

Table 2. Corelation of major parameters in study area

Parameter	pH	EC	TDS	Hardness	Ca^{++}	Mg^{++}	Na^+	K^+	Cl^-	SO_4^{--}	HCO_3^-	F^-
pH	1											
EC	-0.60	1.00										
TDS	-0.60	1.00	1.00									
Hardness	-0.57	0.99	0.99	1.00								
Ca^{++}	-0.60	0.97	0.97	0.95	1.00							
Mg^{++}	-0.34	0.73	0.73	0.79	0.56	1.00						
Na^+	-0.73	0.98	0.98	0.97	0.95	0.70	1.00					
K^+	-0.57	-0.09	-0.09	-0.11	-0.09	-0.11	0.03	1.00				
Cl^-	-0.60	0.99	0.99	1.00	0.95	0.77	0.97	-0.12	1.00			
SO_4^{--}	-0.61	0.98	0.98	0.99	0.98	0.70	0.98	-0.06	0.98	1.00		
HCO_3^-	0.65	-0.93	-0.93	-0.93	-0.89	-0.74	-0.91	0.12	-0.95	-0.89	1.00	
F^-	0.47	-0.34	-0.34	-0.28	-0.24	-0.29	-0.30	-0.48	-0.31	-0.22	0.43	1.00

Table 3. Statistical analysis of groundwater in study area

Parameter	pH	EC	TDS	Hardness	Ca^{++}	Mg^{++}	Na^+	K^+	Cl^-	SO_4^{--}	HCO_3^-	F^-
Min	7.1	1830	1171	350	60	1.1	160	1	158	120	30.012	0.5
Max	8.2	13840	8858	4700	1376	432	1050	2	4620	475	400.16	0.8
Average	7.39	7798.57	4991.14	2245.71	633.71	158.90	657.14	1.43	2235.57	285.71	218.62	0.70
Std.dev	0.41	5124.05	3279.45	1812.16	538.67	162.36	333.70	0.53	1806.48	149.48	146.52	0.13
Median	7.2	7330	4691	2000	800	84	720	1	1904	320	250.1	0.8

Table 4. Time series analysis of TDS and Cl in study area

Sr. no	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Month	3/87	3/88	5/89	5/91	4/94	5/94	6/94	7/94	8/94	10/94	12/94	1/95	2/95	3/95	6/95
TDS mg/L	6200	4700	4700	3000	1792	1664	1500	1300	922	774	742	749	800	877	1174
Cl^- mg/L	5240	4950	2860	1430	844	1426	1400	1386	286	226	326	358	376	426	536
Sr. no	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Month	7/95	9/95	10/95	11/95	12/95	2/96	8/96	7/97	9/97	10/97	11/97	3/98	4/98	7/98	9/98
TDS mg/L	1024	957	906	800	800	1178	1050	950	2310	2221	1894	1996	1740	1171	2240
Cl^-l mg/L	476	426	396	315	315	700	350	175	420	420	333	345	140	158	651

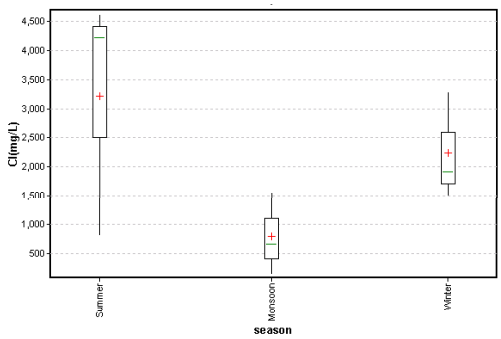

Figure 1. Box-whisker for Cl at SHIN-17 for the period 15-7-1988 to 3-6-1999

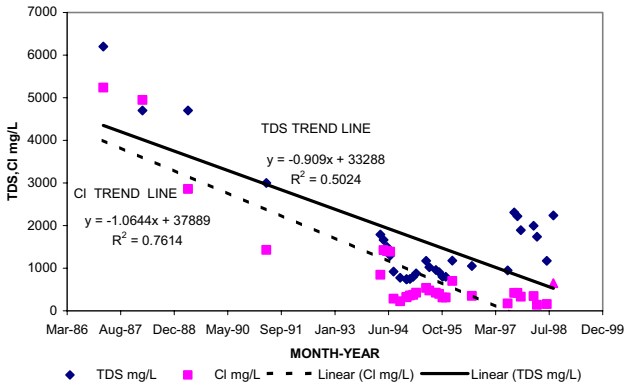

Figure 2. Time series plot

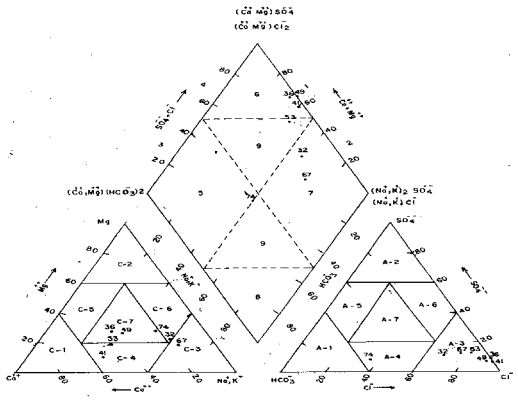

Figure 3. Piper trilinear diagram of groundwater of the study area

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